literature, we find that the current rate of embolization is the same as was found in a 2004 survey of AGA proctors,[5] whereas the PER rate is 3 times that reported in 2004 by AGA investigators.[4] Embolized devices often require operative intervention, and there is a risk of damage to cardiac structures with catheter removal. Comparison of thromboembolitic event rates with other publications reveals that it may be a bigger problem than is currently believed. Only 1 such complication was found in 3 major studies (including 2 specifically aimed at detecting thrombosis rates),[9-11] and a report in 2006 claims to be first to report stroke from an Amplatzer device.[12]

Comparison with other publications also confirms a lower published rate of death and serious complications than or findings indicate.[13-16] From 2003 to 2006, 5 case reports of device erosion and perforation are found in the literature, and these seem to be accounted for in the MAUDE database.[17-21] Twice before, investigators have published results of the reported PER events from the MAUDE database,[3,22] and there continues to be debate over the cause of this complication. The findings of Divekar and colleagues[22] highlight that larger devices (>25 mm) do not seem to be overrepresented in the known events and that many patients with oversized devices do not experience perforation. We conclude that this seems to be a more frequently encountered complication with a high mortality but make no conclusions about cause.

CONCLUSIONS

The overall mortality for device and surgical closure of the atrial septum seems equivalent, and the need for subsequent operation (surgical rescue) may be more common in patients undergoing device closure than reoperation is in patients undergoing surgical closure. Complications from device closure tend to be serious and most often require urgent or emergency operative management, whereas the mortality for surgical management of a device complication appears higher than that of elective ASD closure. Further information is required in the form of postmarketing surveillance, such as a mandatory user registry with periodic end-user notification.

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Discussion

Dr Carl L. Backer *(Chicago, Ill)*. I want to congratulate Dr DiBardino and colleagues at Children's Hospital Boston for their very clever idea of mining the MAUDE database to determine the incidence of adverse events involving the Amplatzer septal occluder device. I first became aware of this database at the AATS in Toronto in 2004 when Richard Jonas debated Andrew Reddington about this very topic. A brief look at that MAUDE database is quite an eye-opener.

This is a very timely presentation and an important analysis. The issue of device closure was the first paper at the STS in the Plenary Session this year. In that paper, Dr Tara Karamlou also mined a database, the Nationwide Inpatient Sample and ICD-9 procedure and diagnosis codes. She discovered an increased incidence of ASD closure mostly due to a sudden and dramatic rise in percutaneous closure beginning in the year 2001.

The comparison of the MAUDE database to the STS database clearly demonstrates the importance of our own congenital

database. When I debated this topic at the ACC 3 years ago, the cardiologists complained that there is no MAUDE database for surgeons. The STS database is our answer to that issue.

I have three questions for you, and they relate to your numerator and your denominator.

My first question relates to the numerator in your analysis. There were 223 adverse events and 17 deaths related to the Amplatzer device. At the AATS meeting in 2006, when we had a similar discussion, I asked this audience how many people had taken Amplatzer devices out of various parts of the body; nearly everyone in the room raised their hand. Is it possible that the MAUDE database might only be capturing the tip of the iceberg, and how confident are you in your numerator?

Dr DiBardino. Thank you Dr Backer. That's a tricky question to answer. I presented this data to the interventional cardiologists in Boston before I left and it's their sense that this is the tip of the iceberg. There are folks who place these devices who don't know about the MAUDE database. And that makes me very suspicious that our numerator is, in fact, grossly under-reported.

There was an interesting study published by the United States General Accounting Office that stated that 0.5% of all device-related complications ever make it to the FDA—0.5%. And that also makes me very wary of this numerator. I think that this is the tip of the iceberg.

Dr Backer. My second question relates to the denominator. The analysis of the predicted complication rate of the Amplatzer device hinges on this number. You noted in your manuscript that a request of AGA Medical was made for an estimate of implants over the time of the study period and that this request was denied. You derived an estimate of 18,333 implants, although the paper you quoted was from 2004. This makes the calculated mortality of the Amplatzer device 1 in 1,000. How comfortable are you with the denominator that you have given us?

Dr DiBardino. Well, the 2 papers that I mentioned (from 2004 and 2007) were both papers that used implants estimates based on AGA medical data and the 2004 paper was published by folks financially tied to AGA medical. So the number 18,333 comes from an estimation that was made of implants over about a 2-and-a-half year period; we simply converted that estimate into ''number of implants per month'' and multiplied it by 66 months, or 5.5 years. I think it's the best we can do. I can't speak to its accuracy because I cannot externally validate it, but I do submit that it is an honest effort and the best we can do.

Dr Backer. And what about the company not responding to your requests?

Dr DiBardino. Well, yes, it was actually interesting. I called the Boston AGA Medical representative (who services Children's Hospital Boston) and asked for the actual implant numbers. They looked into it, and I received an electronic mail correspondence subsequently that said that that information would not be available for me. I just can't get it.

Dr Backer. All right. My final question relates to the incidence of complications in the MAUDE database over time. It was a little disturbing to see that slide that showed that actually the number of reports are increasing per year. This could possibly be related to an increase in the total number of devices implanted or that there is not a positive learning curve that we would hope would happen. When we discussed this in 2006, Dr del Nido noted that the interventional cardiologists are now looking at things like the size of the aortic rim, not oversizing the device, more careful follow-up, and that this would, indeed, actually reduce the incidence of these complications. What's your feeling, looking at this database, whether the incidence of these complications is going up or down over time?

Dr DiBardino. Well, the histogram that I showed is not very useful because it, of course, does not answer the question about whether the increase in reported events is simply that people are reporting them more often or are they being implanted more often such that the frequency of complications cannot be ascertained. The cardiology literature does comment on the fact that, after the device was first approved for general use, there was perceived to be a rise in the complication rate and this has been ascribed to the unfamiliarity of new cardiologists to that device. Beyond around 2004–2005, we sort of lose track of that in the literature. I really don't have enough information to truly accurately know what the trend is in complication rate.

Dr Jeffrey P. Jacobs (*St. Petersburg, Fla*). First, I would like to congratulate you for doing a great job and making an outstanding presentation. It really makes me proud to see our database, the STS Congenital Heart Surgery Database, mature to the point that it can be used for a study like this one. I think you did a great job with this study and presented it quite well.

I think one could criticize the data from the STS database by saying that it stops at hospital discharge, and we do not know what happens after hospital discharge. This criticism underscores the importance of what we are trying to accomplish in the STS database by incorporating HIPAA Compliant Unique Patient, Surgeon, and Hospital Identifier Fields into the STS Database, and creating a framework where our database can be used as a tool for longitudinal follow-up. The STS Adult Cardiac Database has incorporated these identifier fields as of January 1, 2008. These fields will be incorporated into the STS Thoracic Database on January 1, 2009, and into the STS Congenital Heart Surgery Database on January 1, 2010. I think that this accomplishment is going to mature our STS database.

My question is: How would you recommend maturing the way that we follow these devices, and the device databases, based on what you have learned from this study?

Dr DiBardino. Thank you, Dr Jacobs. In my time as a junior resident in general surgery in Dr Chuck Fraser's research lab, I became interested in databases and outcomes analysis and hope to make that the backbone of my own academic career as I progress.

I think the answer to your question is that if you look at the history of the FDA in cardiovascular surgery, there are numerous examples (the Bjork-Shiley prosthesis, the Silzone coating that was transiently used on St. Jude valves) of where postmarketing surveillance has become important. Even changed the way products are handled, what their recommendations are for their placement and, in some cases, products being eliminated from the market. I think what we're not going to have is a head-to-head trial. It's just not going to happen. I think an easy solution would be simply creating a registry, an implant registry, with periodic end-user notification. That has been done with LVADs; it is easy and effective and it would give us real answers about what the numerators and denominators are.

Dr Shunji Sano (*Okayama City, Japan*). Just over one year, we studied the Amplatzer ASD closure. In the last year, our cardiologists

have done 94 Amplatzer ASD closures and defend the first-year closure on 10 patients. And we have no host mortality and no surgical rescue, one temporary episode of thromboembolism. So the result is completely different from yours. I think maybe the difference is the indication. If you have wide range of indications, you have more complications.

The question is: Do you have surgeons involved in the indication of Amplatzer ASD closure and surgical closure? Because we, in our unit, the surgeon is completely involved in the indication of the technique, 2 techniques, and our young surgical fellow is also involved in this procedure.

Dr DiBardino. Well, I think what you're describing is very common when you examine the results from a single center that has excellent physicians who are doing procedures that they are very experienced with. And if you look at single-center reporting from the United States, you'll find the results that you've just described: No mortality, no erosions, no embolizations. But when you apply a product to the general audience and you allow people who are less familiar with it, then, to start using it, there is going to be a learning curve. And I think that's part of what we're seeing in this analysis.

In Boston, the surgeons are not involved in the decision, by and large, to place implants or devices. One thing I will say, however, is that our interventionalists (one of whom is my coauthor on this paper) are gifted and talented but also careful. What I mean to say is that they are very careful about their selection and techniques in terms of using stop-flow technique for balloon sizing, paying careful attention to the amount of retro-aortic rim, and being very careful not to oversize devices. They're probably more careful about it than they are at some other places and there not afraid to send certain patients to the operating room. All of this leads, as it has at your center, to a low complication rate. But I think that it's difficult to extrapolate those results to everywhere, all over, because of the different comfort level and skill level of the physicians who provide care.